Grid Operations & Integration: Barriers and Opportunities for Wind Generation

"Windiana" 2010

July 21, 2010
Indianapolis, IN

Robert Zavadil
Executive Vice President
620 Mabry Hood Road, Suite 300
Knoxville, Tennessee 37932
Tel: (865) 218-4600 ex. 6149
bobz@enernex.com
www.enernex.com

Interconnection vs. Integration

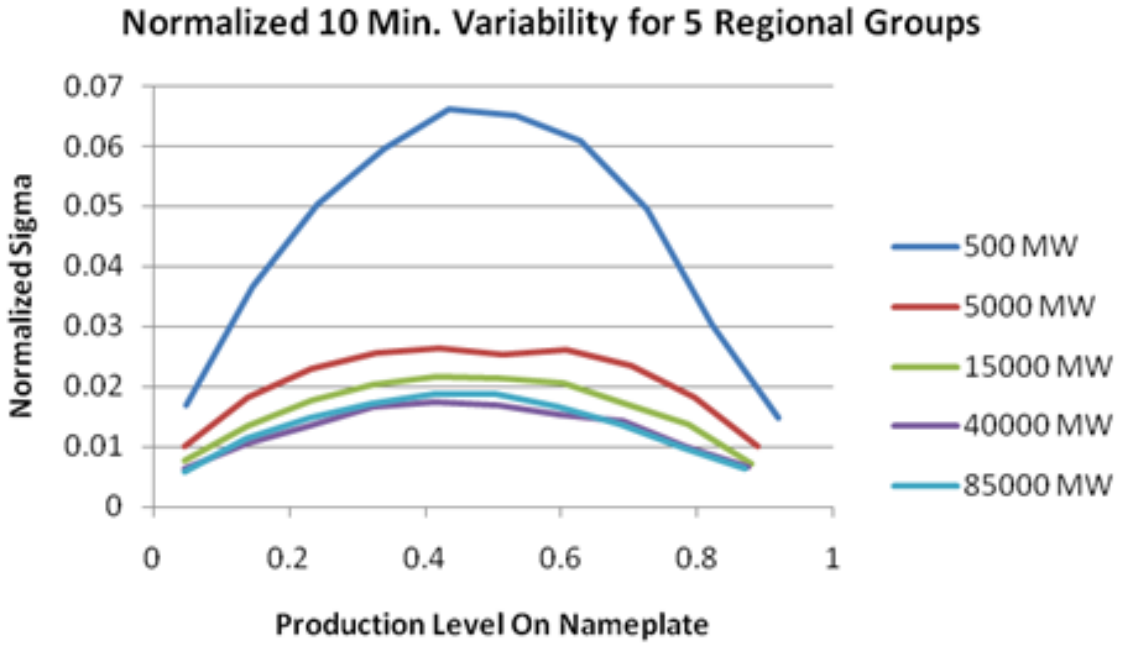
- Convenient categories for many issues and challenges related to wind generation
- *Interconnection*
  - Questions are primarily technical, centered on transmission network
  - Thermal, voltage, transfer limits
  - System stability and security
  - Focus in on events, contingencies, abnormal conditions
- *Integration*
  - Larger emphasis on economics
  - Involves interaction of all generators with all loads
  - Transmission capacity also plays a role
  - Focus on “normal” operating conditions

Grid Integration: Status

- Integration studies
  - Continue to provide important insight regarding possible “futures”
  - Scope and scale on the increase:
    - » company → region → interconnection
    - » Benefits of large operating pools especially apparent
- Findings
  - Integration costs are not zero, but so far they are shown to be modest (~$5.00/MWH of wind)
  - Diversity has significant benefits
  - Large balancing areas / modern energy markets facilitate wind integration
    - » Larger number and type of supply resources
    - » Optimization over larger footprint less sensitive to wind-introduced uncertainties
  - **High penetrations (e.g. 20%+) are manageable (re: EWITS and WWIS)**

Diversity Benefits

- Both variability and uncertainty of aggregate wind decrease percentage-wise with more wind, more geographic area
- Transmission is key to exploiting this phenomena



New Issue: "Winners and Losers"

- Recent studies (i.e. EWITS and WWIS) considering large amounts of wind that have substantial influence on energy supply picture
- With wind as price-taker, less energy from other/existing resources
- Conventional capacity may be/likely needed for reliability, operating reserves
- How are displaced conventional resources "made whole"?

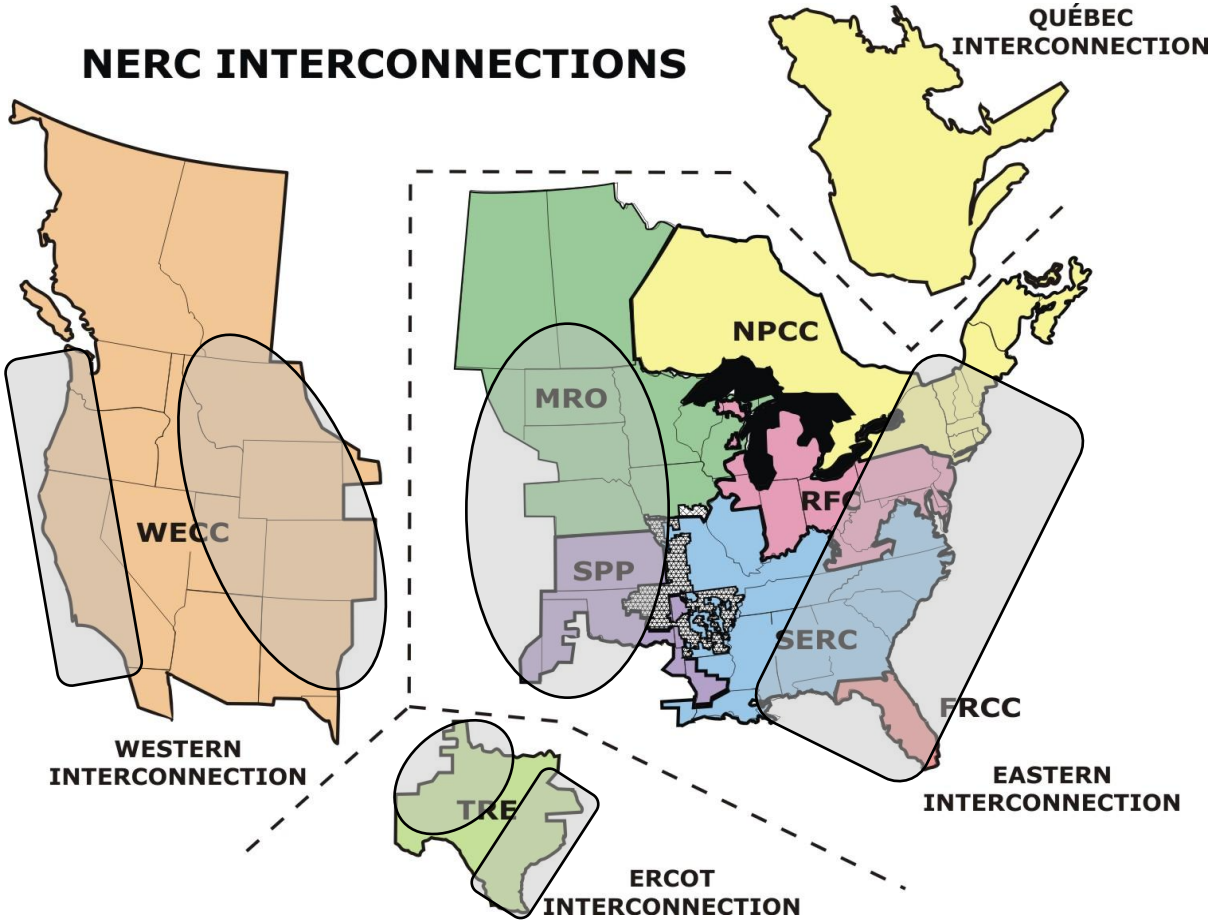
Actual Grid Integration Experience is Growing

- Significant wind in some markets/operating areas
- Issues experienced by operators being evaluated, and remedies proposed and implemented
  - Market structure
  - Ramp and other operating issues
  - Cost allocation for integration services
- Focus on forecasting is increasing significantly
  - UWIG Forecasting Workshop (February 2010)
  - Research, pilot programs
  - Market and operation integration of forecasting data
  - Much more work to be done here

Transmission and Grid Integration

- Current situation:
  - Installed U.S. wind generation capacity ~35 GW
  - <2% of annual U.S. electric energy use
- Predictions from an (AWEA) sage!
- Transmission is already a limitation on wind development in many regions of the country
  - ERCOT
  - MISO: Dakotas, Minnesota, Iowa
  - Inter-Mountain West and Desert Southwest
- Development still continuing, but congestion and curtailment are facts of life

Lots of wind, Lots of load, Lots of distance



Best Onshore Wind Resources

Highest Load

Traditional Transmission Expansion: How we got the grid we have

- Established rationale for transmission expansion
  - Connect generation to load
  - Maintain system reliability
  - Economic energy exchanges with neighbors
- Perspective
  - Initially on an individual company basis
  - Interconnections with neighbors increased scope
  - Emergence of wholesale energy markets has lead to a regional view
- Is the regional view adequate for remote renewable resources?

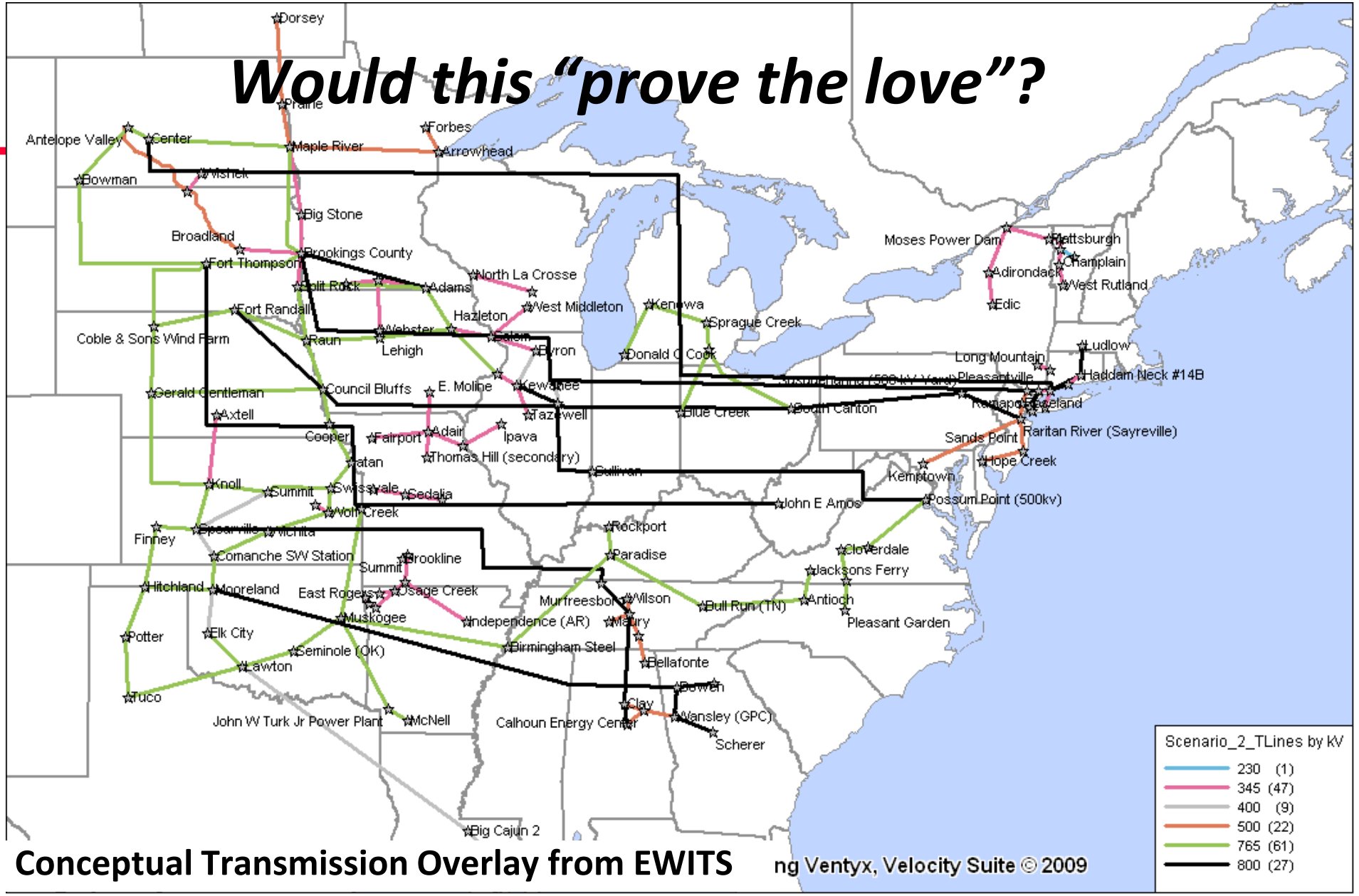
Going Forward

- Further substantial wind energy development and transmission are tightly linked
- Regional transmission can support additional development in near term
- Aggressive wind development requires a broader view

Innovative Approaches to Breaking the Transmission Logjam

- Achieving high penetrations of wind energy – e.g. 20% - will require very substantial wind development and therefore significant grid expansion.
- Transmission is stymied in many regions due to cost allocation, cost recovery, siting and permitting, and NIMBY issues
- Identify renewable energy zones
- Build transmission in advance of need
  - Transmission lead times are 7-10 years
  - Wind plant lead times are 1-2 years
- Break out of traditional cost recovery methods
  - Socialize the cost
  - Pay for lines with LMP differences
  - Let TSO recover cost in rates until wind plants come
- If you ***love*** wind, you gotta at least ***like*** transmission!

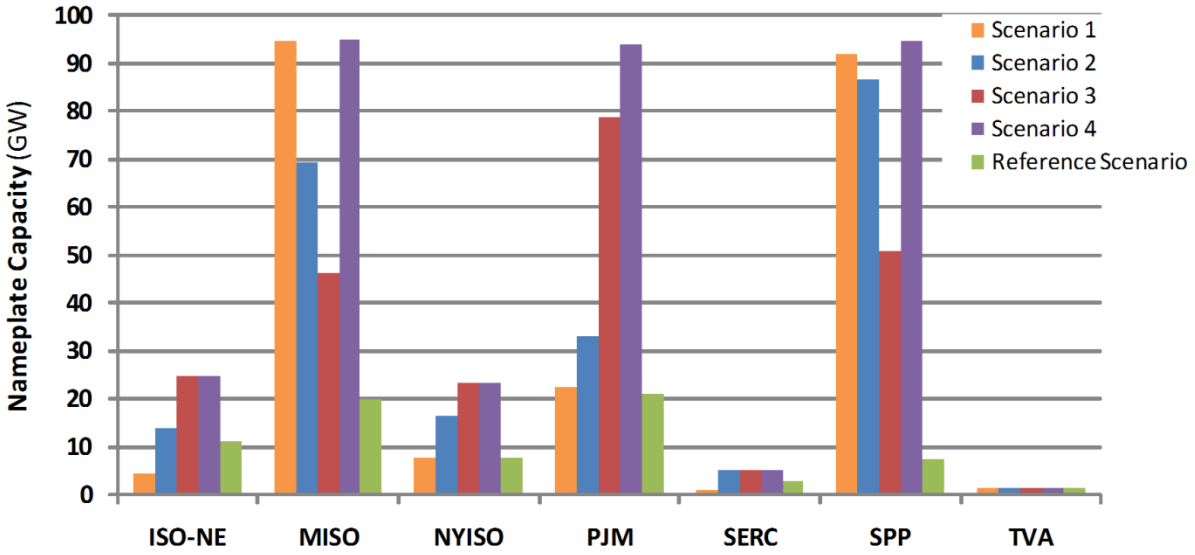
Would this "prove the love"?



Conceptual Transmission Overlay from EWITS

EWITS:
Regional Wind Penetration by Scenario

- Very high penetrations in SPP for all scenarios
- Atlantic off-shore amount increases substantially in S3 & S4.
- Installed wind generation capacity
  - 20% ≈ 230 GW
  - 30% ≈ 330 GW



Capacity Factor Comparisons:

West = MISO + SPP
East = ISO-NE + NYISO

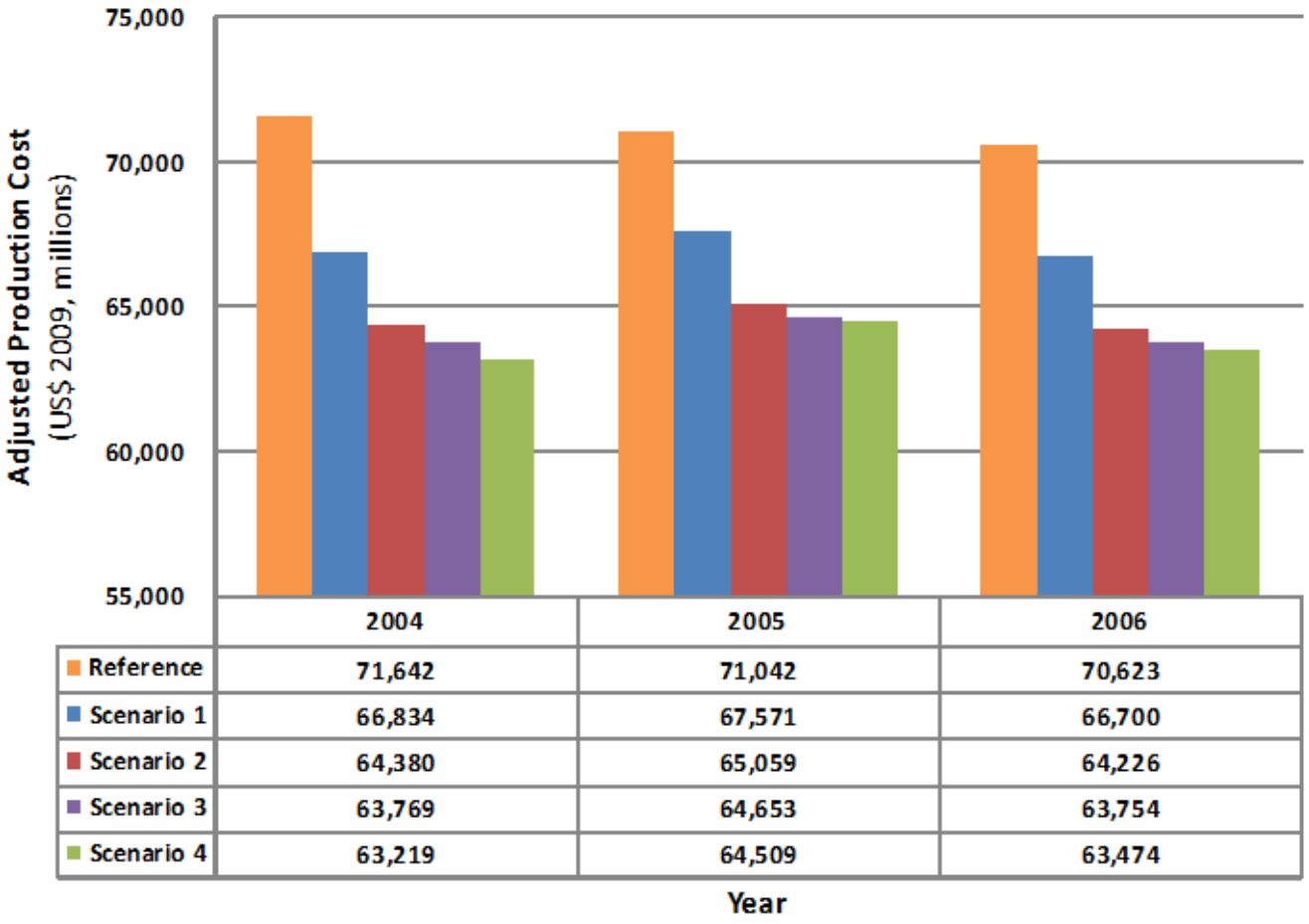
Scenarios

	East	West
Scenario 1	33%	40%
Scenario 2	34%	40%
Scenario 3	36%	39%
Scenario 4	36%	40%

Entire Database

	Land Only	W/offshore
West	38%	
East	31%	36%
East + PJM	30%	36%

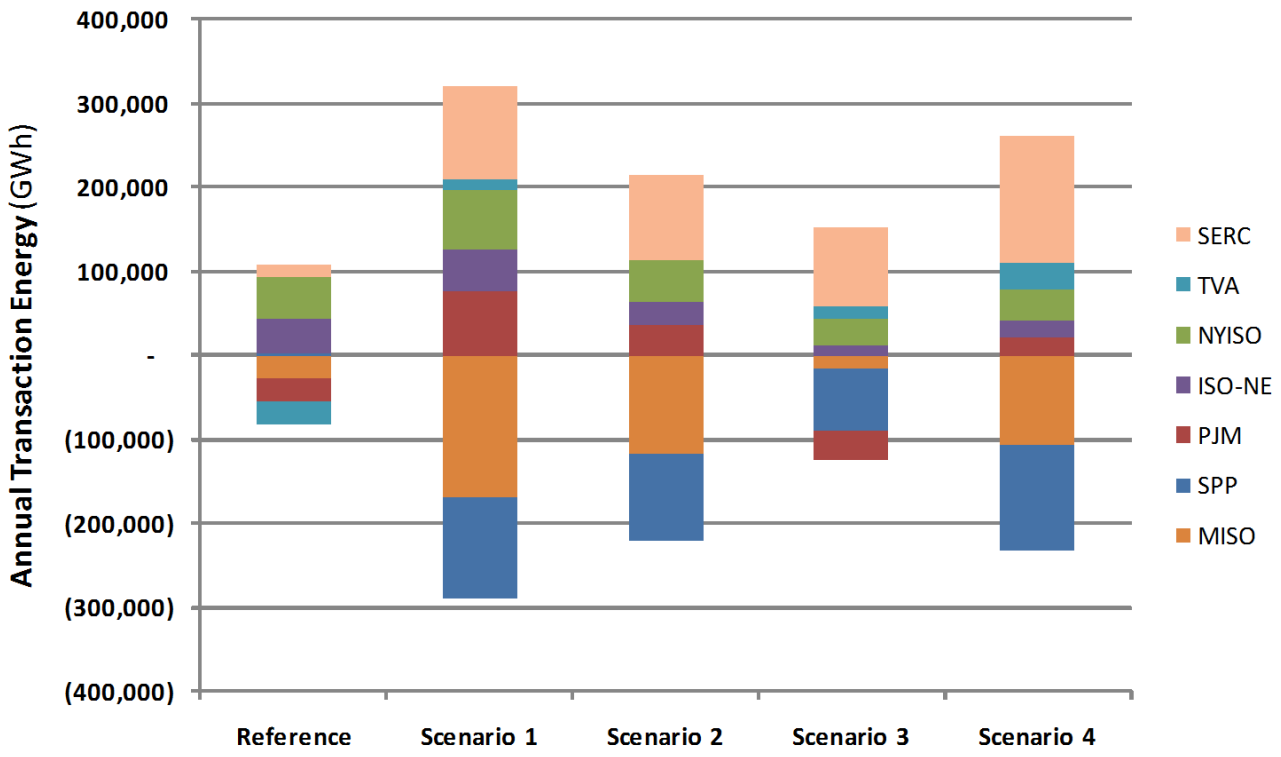
Impacts on Production Cost



	2004	2005	2006
Reference	71,642	71,042	70,623
Scenario 1	66,834	67,571	66,700
Scenario 2	64,380	65,059	64,226
Scenario 3	63,769	64,653	63,754
Scenario 4	63,219	64,509	63,474

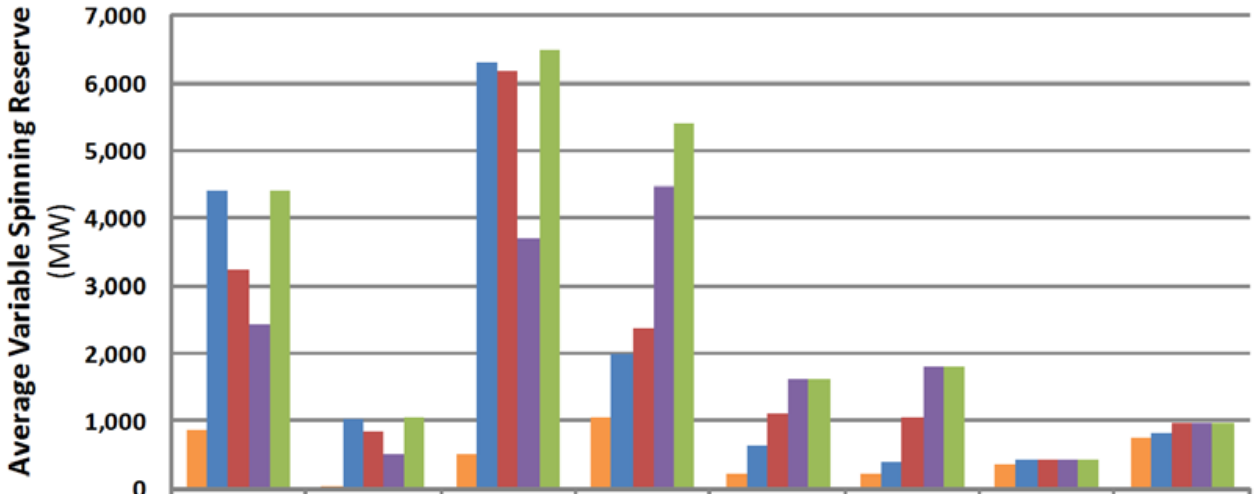
Effects on Regional Energy Transactions

- MISO & SPP are net exporters in all scenarios
- PJM is net exporter in Scenario 3
- Scenario 3 has lowest transaction energy



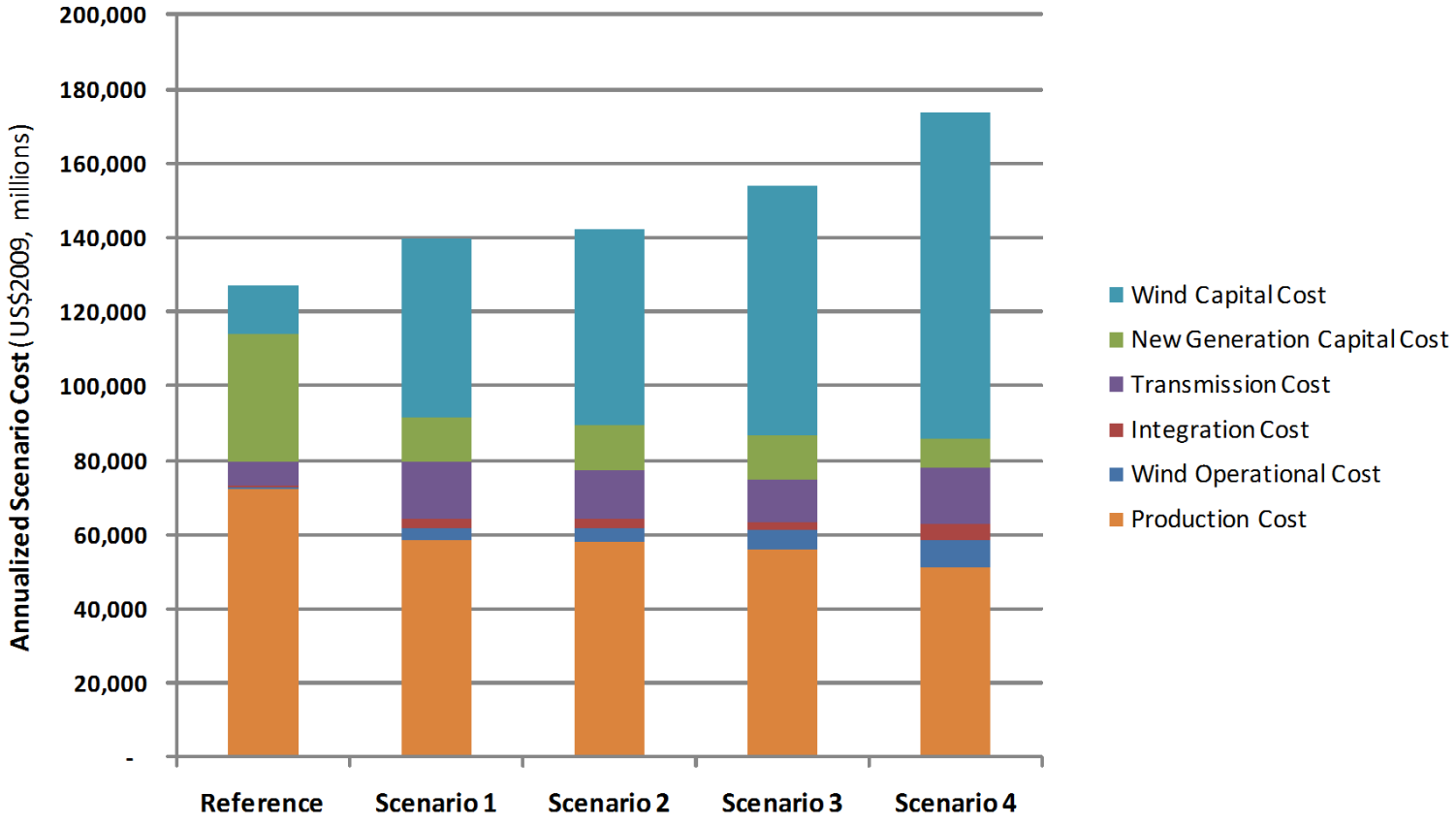
Results – Reserve Requirements

- Wind variability (as function of generation level and scenario) use to calculate incremental regulation amount
- Results is a profile that varies hourly with the amount of wind generation



	MISO	MAPP	SPP	PJM	NYISO	ISO-NE	TVA	SERC
Load Only	885	43	514	1055	217	202	365	741
Actual Wind S1	4,424	1,020	6,308	1,994	618	399	420	816
Actual Wind S2	3,245	835	6,176	2,359	1,118	1,046	418	955
Actual Wind S3	2,419	503	3,695	4,463	1,614	1,789	418	955
Actual Wind S4	4,423	1,038	6,487	5,410	1,614	1,789	418	955

Scenario Cost Comparisons



EWITS Conclusions

- High penetrations of wind generation—providing 20% to 30% of the electric energy requirements of Eastern Interconnection—are technically feasible with significant expansion of the transmission infrastructure.
- New transmission will be required for all the future wind scenarios in the Eastern Interconnection, including the reference case. Planning for this transmission, then, is imperative because it takes longer to build new transmission capacity than it does to build new wind plants.
- Without transmission enhancements, substantial curtailment of wind generation would be required for all of the 20% scenarios.
- Interconnection-wide costs for integrating large amounts of wind generation are manageable with large regional operating pools, where benefits of load and wind diversity can be exploited and large numbers of supply resources are efficiently committed and dispatched.

EWITS Conclusions

- Transmission helps reduce the impacts of the variability of the wind, which reduces wind integration costs, increases reliability of the electrical grid, and helps make more efficient use of the available generation resources.
- Although costs for aggressive expansions of the existing grid are significant, they do make up a relatively small piece of the total annualized costs in any of the scenarios studied.
- Wind generation displaces carbon-based fuels, directly reducing carbon dioxide (CO_2) emissions. Emissions continue to decline as more wind is added to the supply picture. Increasing the cost of carbon in the analysis results in higher total production costs.

Some Other Findings and Conclusions

- Achieving 20% energy penetration across the Eastern Interconnect will require very substantial wind development and therefore significant grid expansion.
- A single iteration of the economic transmission expansion methodology provides useful results and insights
- Further iterations would allow overlays to be improved, wind curtailment to be minimized
- Costs should be considered rough estimates based on a singe iteration of the process. Further engineering evaluation would be necessary to sharpen capital cost estimates and develop chronological plan to evolve existing grid

Coming Emphasis on *Interoperability*

- Wind is visible, and policies are being developed and implemented for operating with significant wind
- Exchange of data and information among stakeholders in real-time will be critical
  - Wind plant operators
  - Grid operators
  - Forecasting entities
- Current architecture for this information exchange is difficult to scale
- Standards are coming (e.g. 61400-25 “Wind Plant Communications and Control”)

Interoperability Opportunities

- Better operations through use of appropriate wind generation forecasts = fewer operational issues related to wind generation
- Interoperability will also facilitate future opportunities for wind generation
  - Participation in ancillary service markets
  - e.g. some curtailment could become “Down-Regulation”

Thanks

Robert Zavadil
Executive Vice President
620 Mabry Hood Road, Suite 300
Knoxville, Tennessee 37932
Tel: (865) 218-4600 ex. 6149
bobz@enernex.com
www.enernex.com